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PETROLEUM EXPLORATION, PROPERTY RIGHTS AND EXTERNALITIES IN THE CANADIAN ARCTIC ISLANDS

by

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1. INTRODUCTION

Extensive exploration for oil and gas in the Canadian Arctic Islands began in 1960 when the Canadian Oil and Gas Regulations were promulgated by the Government of Canada. These regulations were designed to allocate exploration and production rights to the Arctic Islands and to extract the public's share of resource rents. Since establishing this system of property rights, the Government of Canada has also intervened in exploration more directly by acquiring a 45% equity position in Panarctic Oils Ltd., formed in 1967, and by creating Petro-Canada in 1975, the national energy company.

The purpose of this paper is to examine critically how the system of property rights inherent in the oil and gas regulations and subsequent amendments (particularly the proposed Petroleum and Natural Gas Act[1]) and the more direct forms of intervention via Panarctic and Petro-Canada have influenced exploration activity in the Arctic Islands.[2]

The framework for analyzing the Government of Canada's role in influencing events in the Arctic Islands is the market failures doctrine. The market failures doctrine argues that the unhindered operation of competitive markets will obtain an efficient allocation of resources unless certain characteristics of the goods or markets in question result in what is termed a market failure. Sources of market failure that will be of concern in this paper are economies of scale and externalities. If unit costs decline as the scale of an activity increases, then the activity is said to exhibit economies of scale. If the activity of an individual or firm confers costs or benefits on other individuals and/or firms then the activity is said to result in an externality. Market transactions between interested parties may fail to realize completely economies of scale and externalities because market transactions are costly. These transactions costs depend on the system of property rights.

I will argue that the initial system of property rights devised by the Government of Canada retarded the development of the Arctic Islands. Development was inhibited by the fact that exploration rights were spread over too many individuals and firms. This diffuse pattern of ownership made it costly for the interested parties to realize the economies of scale and to internalize externalities inherent in explorations in frontier areas through market transactions.

Petroleum exploration and production in frontier areas such as the Arctic Islands of northern Canada differ significantly from similar activities in such well developed areas such as the Province of Alberta.[3] Firstly, the Arctic Islands are much less explored; secondly, the distance to populated areas and customers in southern Canada and the U.S.A. is much greater; thirdly, no facilities to transport gas and oil to markets exist to date; finally, the environment and geography pose special problems. I will argue below that these factors result in substantially greater risks,[4] increasing returns to scale, and potential externalities in the exploration, production, and transportation of oil and gas.

The most efficient way of developing the petroleum resources of the High Arctic is through large scale or unitized exploration. This is substantially the procedure today. Panarctic Oils Ltd. has the most extensive land holdings in the Canadian Arctic Islands. This consortium of 19 private firms and the Government of Canada emerged as a consequence of both the economies inherent in large scale exploration and the initially fragmented pattern of ownership.

Petro-Canada has recently acquired the Government of Canada's interest in Panarctic and has entered into joint ventures with privately owned firms. Furthermore, the proposed new Oil and Gas Regulations give Petro-Canada a special role in frontier exploration. The merits and demerits of these events are discussed below.

The paper proceeds as follows. In section 2 we provide a brief historical sketch which illustrates how the initial fragmentation of ownership inhibited exploration in the Arctic Islands. In the following three sections we analyze economies of scale and externalities peculiar to frontier exploration and ascertain which government instruments are effective remedies. Section 6 examines critically the case for government intervention in the form of Panarctic, Petro-Canada and proposed changes to the Canadian Oil and Gas Regulations.

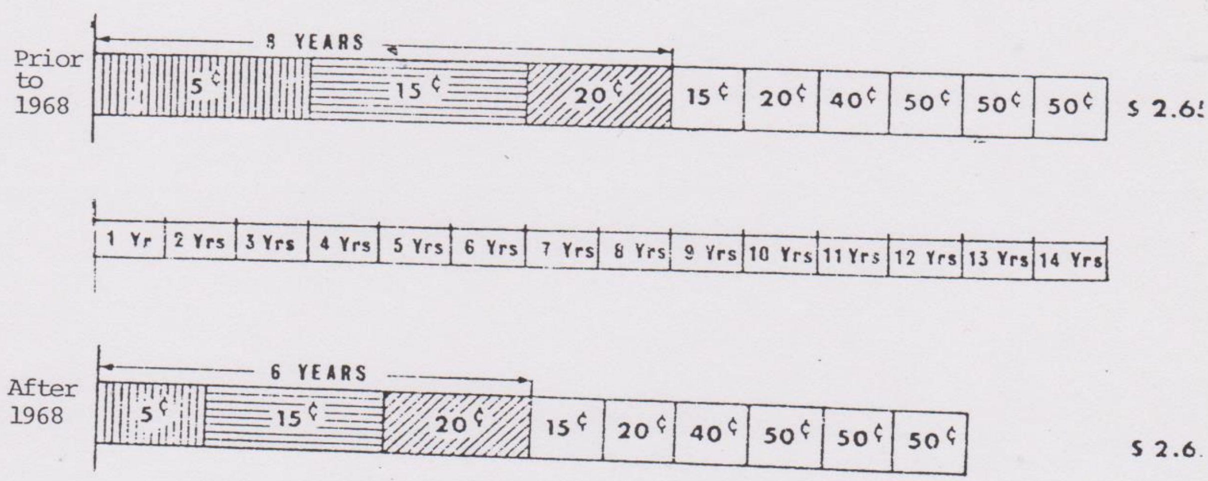
2. EXPLORATION IN THE CANADIAN ARCTIC ISLANDS

The Canadian Government opened the Arctic Islands for petroleum exploration in June 1960. Previously the Geological Survey of Canada had conducted geological and geophysical reconaissance. These activities established that large quantities of hydrocarbons might exist in the sedimentary rocks of the Sverdrup Basin. After the Canada Oil and Gas Land Regulations came into effect on June 6, 1961, a large number of individuals and small to intermediate sized mining and oil companies obtained permits of exploration for a substantial portion of the Arctic Islands and offshore areas.

These exploration permits conveyed the following rights and obligations.[5] An applicant could select a grid area that was not already under permit from a master map held in the Oil and Mineral Division at Ottawa. After paying a 250 dollar permit fee and a deposit in the form of cash, bonds, or promisory notes to guanrantee that exploratory work would be done, the applicant would be granted a permit entitling him to explore for oil and gas.

The holder of an exploration permit was entitled to explore the property for an original term of eight years with six one year renewal terms. During the life of the permit the holder was required to spend at least $2.65 per acre on exploration. This work expenditure requirement started at 5 cents per acre per year and escalated to 50 cents per acre per year as shown in Diagram 2.1.

DIAGRAM 2.1



During the term of the permit, the holder could acquire a renewable production lease, valid for twenty-one years, covering up to fifty per cent of the property. The rental fee was 50 cents per acre for the first year and $1.00 per acre in subsequent years. Up to fifty per cent of the annual rental could be in the form of unallocated work expenditures carried forward from the permit stage. The public's share of the resource rents were collected as follows.

The permittee had the option of acquiring a production lease to the remaining property by paying, in addition to the rental fee, a royalty which varied with the location and extraction rates. If the option was not exercised, the Crown could sell by tender either the production rights or exploration rights to the property.

Exploration permits are not transferable from one party to another. However, it is common for a permit holder to "farm out" his land for exploration by another party upon mutually agreeable terms or to receive funds for exploratory work on his property from his neighbours.

By 1966 approximately 65 million acres were under exploration permit. Howevery only 3 wells had been drilled, one in each year during the period 1962-64. All were dry and were abandoned. The permit holders in 1966 did not have sufficient financial resources or expertise to mount, individually, an effective exploration of their land holdings. Given the terms of the exploratory permits, the permit holders were in danger of paying substantial permit feess or losing their rights if exploration obligations were not fulfilled. The solution was to form a consortium and unitize exploration. Incentives to unitize exploration in the Arctic Islands were the following.

Firstly, large amounts of capital were required to develop new seismic and drilling technologies capable of coping with the severity of the Arctic environment. Secondly, given the remotness of the Arctic Islands from the populated areas of Canada, substantial increasing returns to scale due to set-up costs exist in drilling, extracting, collecting, and transporting the oil and gas. Thirdly, information obtained from drilling a well may change the probability of discovering oil or gas when drilling wells on neighboring parcels of land. Individuals who drill may be prevented from appropriating, expost, the full value of the information because of the cost of preventing either the sale of information by such insiders as members of the drilling crew or resale and other collusive arrangements among owners of neighboring parcels. Fourthly, the economic viability of constructing a transportation system requires that threshold levels of oil and gas be found. The expected return from exploration depends on the period of time until transportation facilities are built. No return on an investment can be realized until the oil or gas is sold. The individual has an incentive to delay drilling because if others drill in the meantime his estimate of the date that transportation facilities are built and the price at which the oil or gas can be sold may be improved. Finally, there is the matter of the common-property resource problem. This problem has been analyzed in detail elsewhere (e.g., Gordon [1954]) so it is not discussed in this paper.

Initial attempts to unitize exploration were unsuccessful. Exploration permits were held by a large number of individuals and firms. The transaction cost of writing a complex contingent claim contract, a contract whose terms depend on events as they unfold, agreeable to a sufficient number of individuals was substantial. While the initial term of the permits was running out, and therefore the cost of delaying drilling was increasing, transaction costs prevented a sufficiently large number of parties from entering into a joint venture to exploit the economies and externalities. Through the efforts from 1962 to 1967 of Dr. J.C. Sproule of Calgary and a subset of the permit holders, a consortium called Panarctic Oils Ltd. was created in December of 1967, but not before the Government of Canada invested $9 million for a 45% equity in the company. The remaining financing of $11 million was provided by 19 other shareholders. The participation and capital share distribution of these companies is presented in Table A2.

By various contractual agreements with more than 75 companies and individuals, Panarctic obtained the obligations and rights to earn an interest in lands held by these independents. As shown in Tables A2 and A3 these independents "farmed out" their holdings for exploration by Panarctic in exchange for a retained interest in their properties. At the same time Panarctic also acquired exploratory permits on additional acreage from the Crown.

This mode of intervention in the petroleum industry was unique for Canada, although the industry is substantially regulated through taxes, subsidies and price-quantity controls. The intervention was justified by the Government on the basis of special conditions that prevailed in the Arctic Islands, namely, the advantages of large scale exploration.

In the last section of this paper I will discuss this form of intervention in greater detail, and argue that it was beneficial given the initial system of property rights.

Tables A4 and A5 provide statistics on exploration activity in the Arctic Islands from 1962 to 1976. Notice the increased levels of exploration after the creation of Panarctic.

3. ECONOMIES OF SCALE

The remoteness and inaccessibility of the Arctic Islands and their difficult terrain and severe environment have resulted in higher costs for all exploration operations. Generally, exploration costs are ten times the cost of operating in established areas of Alberata.[6] A 10,000 foot well costs from $2,500,000 to $4,000,000. The long distance to the Arctic Islands and the fact that they are accessible only by air during eleven months of the year result in very high set up costs. Supplies which are not shipped up to the Canadian Arctic Islands from Montreal during the short summer must be airlifted. The cost of moving freights to the Arctic Islands by ship is about 8¢/lb., compared to approximately 40¢/lb. by air.

Panarctic has established three base camps which are supplied as much as possible via summer sea lift. The main base camp is at Rea Point on Melville Island; the other staging areas are at Eurelra and Resolute. Once a base camp has been established the costs of operating additional drilling rigs out of that camp diminish rapidly, resulting in large exploitable economies of scale.

Many new concepts and techniques had to be developed to cope with the inhospitable environment. Special drilling equipment and camp units capable of being transported by Hercules (C-130) aircraft had to be developed. A 5,000 foot airstrip is required at each drilling location. Seismic crews and interpretors had to adjust their techniques in order to make the most meaningful use of seismograph shooting. The varying depths of permafrost on land and its possible absence under the seabed make seismic interpretation more difficult and less accurate.

The isolation of the Arctic also contributes to the costs in the form of higher labour bills. To maintain a skilled labor supply, Panarctic adopted a policy of flying drilling crews to Edmonton for a weeks leave after 20 days in the Arctic.

Given these problems and transporation costs, logistics play a vital part in High Arctic exploration. Direct and indirect costs of supply account for about half of every dollar spent on drilling. The overall cost of operating a large rig are approximately $15,000 per day. These logistical costs can be substantially reduced through large scale exploration.

4. THE INFORMATION EXTERNALITY

We now analyze the information externality in the context of a simple but suggestive model. The presence of this externality is well known, particularly among industry participants. Various means are used by the members of the industry to internalize this information spillover. The extent of internalization will depend on the transaction costs involved, which will increase with the disperson of ownership. While this externality has received considerable attention in oil and gas trade journals and by natural resource economists, with the exception of Stiglitz (1975) the problem has not been modelled explicitly. The contribution of this section is to model the information interdependence and to see which government policies are effective in correcting the externality.

Consider the decision problem faced at the start of period t by an individual who holds the exploration rights to a parcel of property. Suppose he believes that, if he decides to drill the probability of hitting oil is θ_t where $0 < \theta_t < 1$. Assume also that he believes that the revenue from the oil, if found, will be R_t dollars and that the cost of drilling is C_t dollars. The alternatives to drilling are either to quite and pay a forfeiture of F_t dollars or to wait andobtain observations which may change his beliefs about the probability of striking oil in the next period. Let the cost of waiting be W_t which includes permit fees and income opportunities foregone. The oil driller's problem is represented by the decision tree in Diagram 4.1.

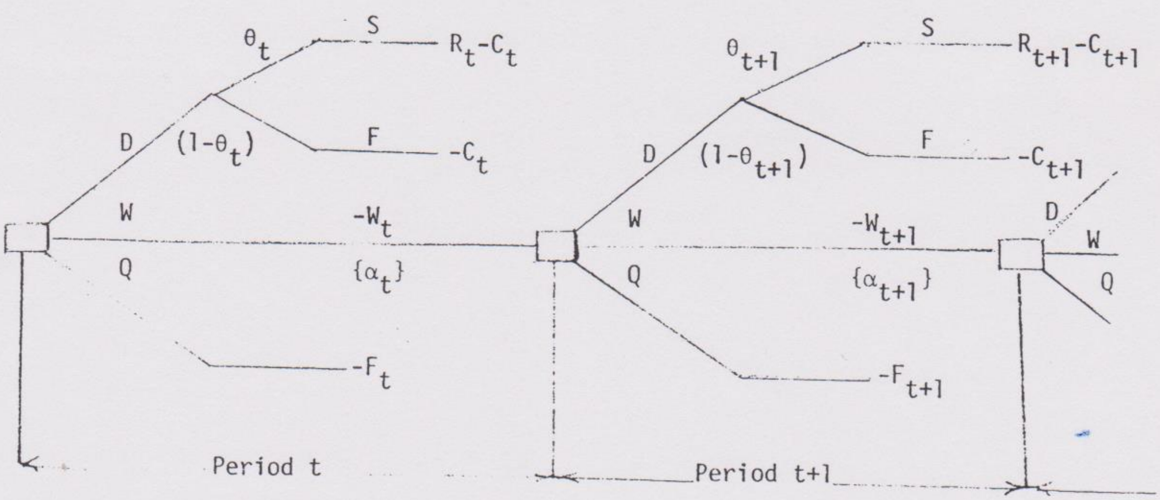


DIAGRAM 4.1

NOTATION:

S = Success, F = Fail

D = Drill, W = Wait and Observe, Q = Quit

R_t = Expected revenue if oil is found in period t

C_t = Expected cost of drilling in period t

W_t = Expected cost of waiting in period t

F_t = cost of forfeiture in period t

θ_t = subjective probability, in period t, of finding oil

α_t = observation in period t

Assuming the oil driller employs Bayesian[7] statistical inferences and decision techniques, we have

$$\theta_{t+1} = \text{Prob}(\theta_t/\alpha_t)$$

= conditional (subjective) probability of finding oil given observation α_t.

The probabilities θ_t and θ_{t+1} are respectively the prior and posterior probability of finding oil. The profit maximizing oil driller will choose that alternative which maximizes his expected present value as of date t:

$$PV_t = \max_{D,W,Q} \{PV_t(D), PV_t(W), PV_t(Q)\}$$

where

$$PV_t(D) = \theta_t R_t - C_t,$$

$$PV_t(W) = -W_t + \frac{PV_{t+1}}{1+r},$$ where r is the rate of interest, and

$$PV_t(Q) = -F_t.$$

Suppose that waiting gives the oil driller no additional information, implying $\theta_t=\theta_{t+1}=\theta$. Comparing $PV_t(D)$ and $PV_t(W)$:

$$\theta R_t - C_t \; : \; -W_t + \frac{\theta R_{t+1} - C_{t+1}}{1+r}$$

we deduce that the oil driller will delay drilling if net revenues in period t+1 exceed net revenues in period t plus the cost of waiting by the rate of interest. If revenues and costs are also expected to be the same in future time periods, i.e. if $R_t=R_{t+1}=R$ and $C_t=C_{t+1}=C$ then there is no gain from waiting and the oil driller should either drill or quit.

To illustrate the value of information and the information externality consider the following situation. Two adjacent properties are owned by different individuals. If individual A adopts the wait alternative in period t then he will observe three possible events relating to his neighbour's activities:

NDS = neighbour drills - success
NDF = neighbour drills - failure, and
NDD = neighbour doesn't drill.

From historical data on properties with similar geological and geophysical characteristics and introspection, individual A could estimate the following conditional probabilities or likelihoods. If there is oil on individual A's property and if his neighbour drills, then the probability of his neighbour discovering oil is β_1=Prob(NDS/S). Similarly, he could compute β_2=Prob(NDS/F), γ_1=Prob(NDF/S) and γ_2=Prob(NDF/F). Using Bayes theorem, the posterior probability of individual A striking oil given the activity of his neighbour is

$$\theta_{t+1}(\alpha_t) = \begin{cases} \dfrac{\theta_t\beta_1}{\theta_t\beta_t+(1-\theta_t)\beta_2} & \text{if } \alpha_t = \text{NDS} \\[2ex] \dfrac{\theta_t\gamma_1}{\theta_t\gamma_1+(1-\theta_t)\gamma_2} & \text{if } \alpha_t = \text{NDF} \\[2ex] \theta_t & \text{if } \alpha_t = \text{NDD}. \end{cases}$$

We would expect that $\beta_1>\gamma_1$ and $\gamma_2>\beta_2$. If this holds then it must be true that

$$\theta_{t+1}(NDS) > \theta_t = \theta_{t+1}(NDD) > \theta_{t+1}(NDF).$$

Given these posterior probabilities, we can compute the present value in period t+1 for each possible realization of α_t:

$$PV_{t+1}(\alpha_t) = \max_{D,W,Q} \left\{ \theta_{t+1}(\alpha_t)R_{t+1} - C_{t+1}, -W_{t+1} + \frac{PV_{t+1}(W)}{1+n}, -F_{t+1} \right\}$$

Then the present value of wainting in period t is given by:

$$PV_t(W) = -W_t+(1/(1+n))\left\{ Prob(NDS)PV_{t+1}(NDS)+Prob(NDF)PV_{t+1}(NDF) +Prob(NDD)PV_{t+1}(NDD) \right\},$$

and the expected value of information obtained by waiting in period t is:

$$EVI_t = PV_t(W) - \max_{D,Q}\{\theta_t R_t - C_t, - F_t\}.$$

If $EVI_t>0$, individual A will wait and observe given the assumed alternatives.

Other alternatives do exist. Individuals A and B could attempt to coordinate their decisions. They could merge their land holdings and treat the properties as one unit, or one individual could pay the other to drill in period t and only make his decision after he observes the outcome of his neighbours drill. In fact this is what we observe in the oil and gas exploration industry.

If these two individuals do not coordinate their decisions then socially inferior drilling patterns may emerge. Both individuals may wait - expecting the other to drill, or both may drill.

To illustrate the optimal drilling pattern consider the following 2 period decision tree where decisions regarding the two drilling sites are co-ordinated and, ex ante, the drilling sites are identical .

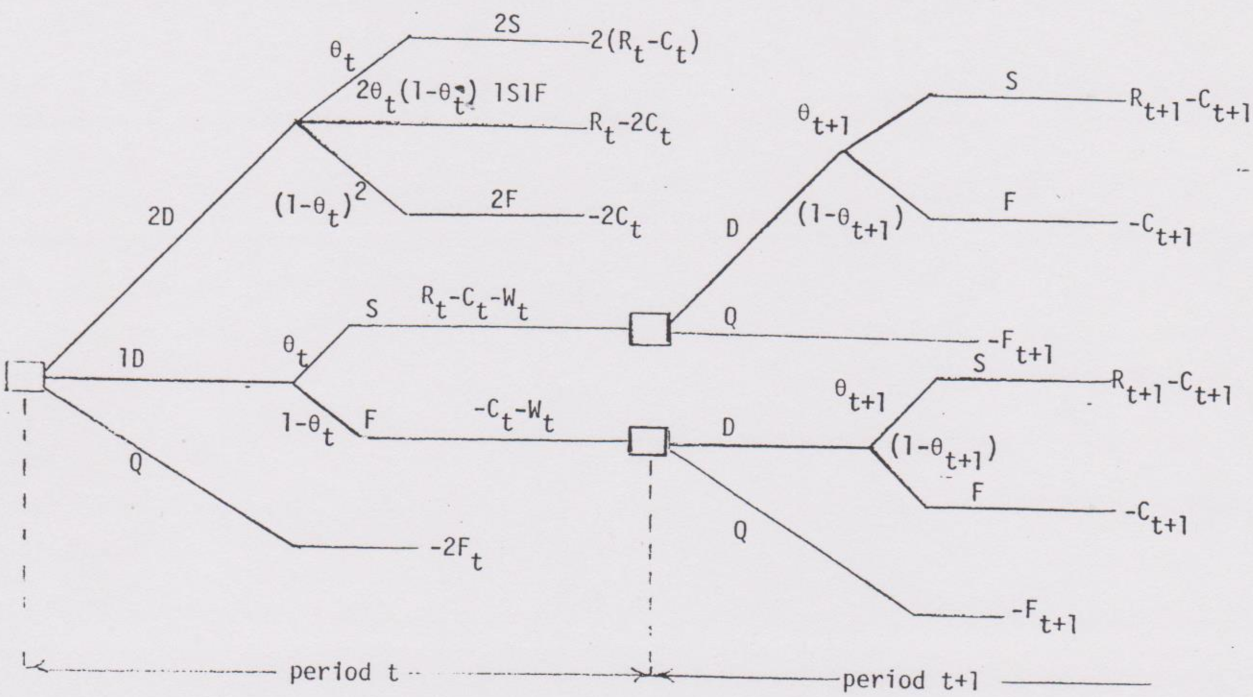


Diagram 4.2

The optimal pattern of drilling, assuming risk neutrality, can be given by determining:

$$P\hat{V}_t = \max_{2D,1D,Q} \{PV_t(2D),\ PV_t(1D),\ -2F_t\}$$

where

$$PV_t(2D) = 2\theta_t^2(R_t - C_t) + 2\theta_t(1-\theta_t)(R_t - 2C_t) + (1-\theta_t)^2(-2C_t)$$

$$PV_t(1D) = \theta_t\ \{R_t - C_t - W_t + (\tfrac{1}{1+r})\max\{\theta_{t+1}(S)R_{t+1} - C_{t+1},\ -F_{t+1}\}\}$$

$$+ (1-\theta_t)\{-C_t - W_t + (\tfrac{1}{1+r})\max\{\theta_{t+1}(F)R_{t+1} - C_{t+1},\ -F_{t+1}\}\}.$$

where

$$\theta_{t+1}(S) = \frac{\beta_1\theta_t}{\beta_1\theta_t + (1-\theta_t)\beta_2}\ ;\quad \theta_{t+1}(F) = \frac{\gamma_1\theta_t}{\gamma_1\theta_t + (1-\theta_t)\gamma_2}\ .$$

Under the same assumptions used above

$$\theta_{t+1}(S) > \theta_t > \theta_{t+1}(F).$$

It is not difficult to assign reasonable numbers to various probabilities such that the optimal drilling pattern is drill one well in period t; if the well is successful - drill another; if the well is not successful - do not drill another.

When this information externality results in interdependent drilling decisions for three or more owners matters become more complicated. The optimal drilling pattern could be quite intricate, depending on the information spillovers resulting from drilling individual or groups of wells in each time period. To internalize the externality through merger or some other contractual agreement among the parties involved could be very difficult. First, there is the matter of reaching an agreement on the various probabilities and conditional probabilities which determine the information spillover. At the bargaining stage, it would be in each individuals best interest to minimize the impact of others drilling on his estimates of success or failure and to maxmize his impact. Given the subjective nature of these conditional probabilities, this form of opportunistic behaviour would be difficult to detect and to eliminate. Second, as the number of parties involved increases, the complexity of the computations required to compute the value of the information spillover increase more than proportionally. Third, as the number of parties to a co-ordinated drilling agreement increase, the potential gains from not being a member (shirking) increase. The consortium may be unable to appropriate the full value of information, because of the high policing costs involved in detecting and preventing either the outsider from observing their activities or the sale of the information to the outsider by insiders or members of the group.

Once a fragmented pattern of ownership has been established, it becomes difficult to devise government policies which will ameliorate any resulting information externality. A system of taxes or subsidies would require that their level be a function of the value of the information. To obtain the correct sequential pattern of drilling would require a well specific, state contingent tax/subsidy scheme where the tax/subsidy on any date would depend on the pattern of events to that date. We have already mentioned how difficult it would be for the parties involved to compute and to agree on these values. A government agency would have the same (if not greater) difficulty in computing the externality.

A government could have its own firm do some of the drilling. In making its drilling decisions, the government firm would take the value of information generated into consideration. This approach would improve socially the pattern of drilling. For example, it would overcome situations where each firm is waiting for the other firms to drill, resulting in no drilling taking place. However, given the potential spillovers from one private driller to another and the computational problems mentioned above, a socially optimal drilling pattern would not (in general) obtain.

The solution, of course, is to take the information externality into consideration at the outset, when the system of property rights is devised. For example, the larger the tract size or area held by one owner, the greater the immediate internalization of the information side effect. In frontier areas, where the initial parameters (mean, variance, etc.) of the distribution of returns from drilling are not known with a great degree of precision, the value of information obtained from an individual drill would be greater than it would be for well explored areas. Ignoring other possible economies, the (socially) optimal tract size would be larger in frontier areas. As we explain in the last section, if exploration rights were put up for public auction or tender, the externalities would be internalized given the available information on the date that the land was alienated from the crown.[8]

5.4 THE THRESHOLD EXTERNALITY

The potential market failure discussed in this section arises out of an interdependency among oil and gas explorers and producers, the transportation and distribution company, and the ultimate consumers. This interdependency may not be resolved completely through market transactions if the number of oil and gas explorers is large relative to the quantity of oil or gas produced. The problem is the following.

Before it is feasible to construct a transportation network linking a region such as the Arctic Islands to markets, adequate proven reserves must exist. The quantity of reserves that must be found (the threshold level of proven reserves) depends on the cost of constructing and operating the transportation network and the expected price at which the oil or gas can be sold. Total recoverable resources from a given area and the expected selling price also have a bearing on the choice of transportation network. Alternative gas transportation systems for the Arctic Islands are the Polar Gas pipeline and tankers with ice-breaking capability carrying liquified natural gas (LNG). To illustrate the problem consider the following diagram.

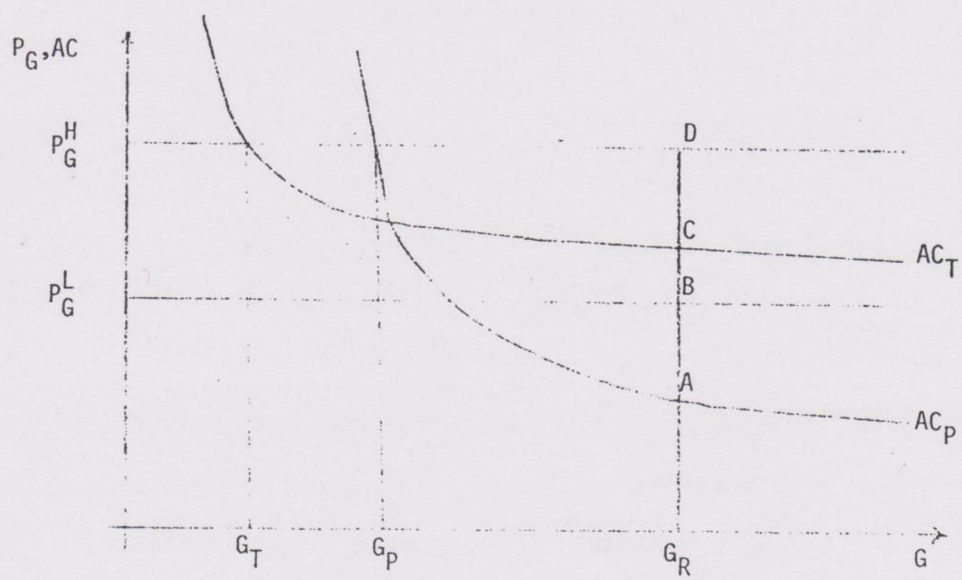


Diagram 5.1

NOTATION:

P_G = price of one unit of gas (net of taxes)

P_G^H = high price P_G^L = low price

AC = average cost schedule of transporting one unit of gas to consumers

AC_T = average cost schedule using tankers, AC_P = average cost schedule using pipeline

G = annual rate of production of gas.

Note: The average cost schedule includes a normal rate of return to the transportation network.

Note that since G represents annual production, the location of the average cost schedules depends on the period of time over which we are amortizing the cost of constructing the gas transportation network. We are assuming that the cost of constructing the gas pipeline is greater than the cost of the tanker system, but that the operating costs of the gas pipeline are lower.

To cover construction and operating costs of the tanker system, at a market price of P_G^H the discovered reserves plus gas expected to be discovered must be great enough to permit a production rate of G_T units of gas per year over the amortization period. To make the pipeline network economically feasible, the reserves must permit an annual production rate of G_P units. Note that at the lower price P_G^L the tanker system is never economically viable.

Suppose that the transportation company expects that enough gas is on hand and will be found to permit an annual production rate of G_R units over the amortization period. At an expected market price of P_G^H both transportation systems are viable in the sense that construction and operating expenses are covered. Clearly the pipeline network permits gas to be delivered at a lower unit cost.

In Diagram 5.1 the distance AD represents the gross expected well-head value of a unit of gas. The transportation company may not pay the gas producer (assuming this is a market transaction) the well-head value of his gas. The price paid the gas producer could be greater or less depending on the terms of the contract between the parties. Note that the expected well-head value depends on the expected selling price, the expected annual production rate, and the type of transportation network that is installed.

The point of this section is the following. Before the transportation network is installed, the expected annual production rate depends on the quantity of gas that is believed to exist in the area to be serviced. This quantity is not known with certainty and knowledge about this quantity (reserves) can be represented by a probability distribution. Information about this distribution is of value to potential transportation companies and to gas producers. A transportation company requires this information to determine the best transportation system. Gas explorers require this information to estimate the date and price at which the gas can be sold.

An individual explorer, when making his drilling decision about the location, number and depth of wells to be drilled, would not take into consideration the effect that his activities have on information about reserves, and the value of this information to other drillers and potential transportation companies. As with the information externality of the last section, transaction costs may prevent the externality from being internalized if property holdings are fragmented.

If exploration is unitized the transaction costs of internalizing the threshold externality will be substantially reduced. The exploration company could build the pipeline itself (integrate forward) or engage in joint ventures (in exploration and pipeline construction) with potential pipeline companies (and with distributors of natural gas).

In fact Petro-Canada, Panarctic, Trans Canada Pipelines Limited, and some potential customers, The Ontario Energy Corporation, Tennoco Oil of Canada Ltd., and Pacific Lighting and Gas are participants in a venture called the Polar Gas Project. The Polar Gas Group was formed in late 1972 with the aim of investigating the feasibility of a natural gas pipeline from the Arctic Islands. Application has been made to the National Energy Board and the Department of Indian and Northern Affairs to construct and operate a natural gas pipeline from the Arctic Islands to southern markets.

Scale model testing by the National Research Council of Canada of a 36,000 ton Polar 7 Class icebreaker has also been completed. The 600 foot, 90,000 h.p. vessel would be the largest and most powerful icebreaker in the world when and if it is built. Vessels of this type would be required if the tanker alternative was chosen to transport liquified natural gas to markets.

6. THE CASE FOR GOVERNMENT INTERVENTION

In this section we will evaluate the economic arguments for intervention in oil and gas exploration in frontier areas using the market failures doctrine of welfare economics. This doctrine argues that unhindered market transactions will lead to an efficient allocation of resources unless there is a market failure.

In Sections 4 and 5 we examined two potential market failures due to externalities. These externalities would arise if the property right system which governed the alienation of exploration and production rights from the Crown and which collected the resource rents, permitted a fragmented pattern of ownership to develop. Transaction costs due to the large number of interested parties involved and due to the difficulty in appropriating the value of the information once produced would prevent these externalities from being internalized.

Attempts by the government to correct this type of externality through a tax/subsidy scheme are fraught with difficulties. The scheme would only work if it was well specific and state contingent. By this we mean that the tax on subsidy applied to a given well at any date would depend on the results of drilling in other locations to that date. Clearly such a scheme would involve very complicated computations and would be very costly to administer.

Intervention by fiat would involve similar problems, although this system could be used to correct for gross departures from what was believed to be the socially desirable pattern of exploration.

The remaining candidates for intervention are joint ventures by the government with private interests, complete or partial nationalization of exploration in the region, and changing the nature of the property rights. In the last decade the Government of Canada has in fact used all three forms of intervention in the Arctic Islands and other frontier areas. They are precisely -- Panarctic, Petro-Canada, and the new Canada Oil and Gas Act respectively.

Some good economic arguments can be made for intervention in the form of Panarctic. Given the fragmented pattern of ownership that developed in the early 1960's, the equity position taken in Panarctic by the government can be looked at as a subsidy to overcome the transaction costs of creating a consortium to unitize exploration. This subsidy permitted the exploration rights to a substantial portion of the Arctic Islands to be held by Panarctic, permitting economies of scale to be realized and externalities to be internalized. Intervention in this form kept involvement by the government to a minimum. Once the market failure had been corrected and exploration was essentially unitized no further intervention was necessary. All that was necessary was to ensure that no further fragmentation in exploration occur, by changing the method by which firms and individuals obtained exploration rights and production leases from the Crown.

Economic arguments for the case of intervention in frontier exploration using Petro-Canada are more difficult to construct. The best argument is that there is a need to delineate Canada's hydrocarbon resource base. To formulate appropriate national energy policies legislatures need information on reserves of oil and gas. Accurate information can only be obtained through exploration. Petro-Canada can play a catalytic role by stimulating exploration in new areas and by developing new exploration, production and transportation technologies. The thrust of the argument is that the social value of exploration exceeds the private value of exploration because of the value of the information to legislatures produced as a by product of the exploration process.

The market failure that is implicit in this argument is that private markets will not place a sufficiently high price on this information from societie's point of view. While Petro-Canada can be used to increase the pace of exploration in frontier areas, traditional fiscal instruments could achieve the same objective. The proposed Petroleum and Natural Gas Act appears to have been designed with precisely this objective in mind.

The old oil and gas regulations were described in Section 2. Important changes in the new regulations are the following:

1. All unalienated lands/Crown Reserves to be disposed of by public tender, or in special cases by Order in Council, may be made available for filing if no bids are tendered. Petro-Canada has certain preferences to acquire Crown Reserves.
2. Production leases to be granted for the entire production area covered by an exploration permit. Public's share of resource rent collected via a 10 percent royalty.
3. Additional economic rent to be collected on discoveries after June 30, 1980 via a Progressive Incremental Royalty (P.I.R.) system in addition to the 10 percent production royalty. Fields will be subject to an incremental royalty above a 25% floor rate of return based upon revenues received after deduction of operating costs, and basic royalty and allowance for investment and income tax.
4. Marked increases in work obligations on existing permits.
5. Issuance of production rights only upon the commencement of production, and for shorter periods of time.
6. Petro-Canada has the option to acquire 25% working interest in all acreage reverting to the Crown under existing permits for the first seven years after the regulations become effective. Petro-Canada must obtain prior government approval for any farm-outs intended with these lands to put a check on the corporation's acquisitions with this provision.
7. Petro-Canada has the first option during the first year in which the new regulations are in effect on the 500 million acres of frontier lands not now under permit or lease.

may go out

8. Petro-Canada is given the option to acquire a 25% working interest in any existing grants for which a special-renewal permit is granted or in any provisional lease issued before a discovery has been made. The company would pay its share of expenditures from the date of its participation, but no prior expenses.
9. The government may order a prospect to be drilled within "a reasonable time period." If the landholder fails to do so, Petro-Canada can be ordered to drill the prospect and earn a minimum of 50% interest.
10. Authorize the Minister or the administering authority
    a) to order the commencements and continuation of production;
    b) to stipulate the posted price of oil and gas production, on the basis of fair market value at field gate or extraction plant;
    c) to order development drilling of discovered reserves.
11. A guideline of 25% as the minimum level of Canadian participation in production licences and for provisional leases when a discovery has been made, below which the Minister may not wish to issue such a lease or licence.[9]

may be stillborn

We will discuss these changes in the regulations by examining their probable impact on:

a) the pace and level of exploration;

b) collecting the public's share of resource rents efficiently; and

c) permitting Petro-Canada to integrate into the exploration stage of the industry.

Points 1, 2, and 3 provide for a superior method of acquiring exploration permits from the Crown and collecting the public's share of resource rents.

With these provisions the common resource problem, economies of scale, and the information and threshold externalities can be internalized at the time lands are alienated from the Crown, based on the information available at that date. Potential permit holders could take these factors into considerations by submitting tenders on sufficiently large areas. Any interdependencies (unforseen or otherwise) that develop after that date can be internalized through contractual arrangements (farm-in/farm-out, etc.) between the parties affected. Under the old regulations an applicant could file on any available area; 50% of the area covered by an exploration permit reverted to the Crown upon application for a production lease. This was clearly inefficient given the advantages, especially in frontier areas, of unitized exploration and development.

Stiffer work obligations and the shorter production leases (points 4 and 5) and the three year holiday on P.I.R. provide an incentive for early exploration of existing permits. The old regulations did not penalize sufficiently those who were not developing their holdings. This encouraged land to be held for speculative purposes, in hope that major fields would be found on neighboring properties.

The highly preferential position given Petro-Canada, detailed in points 6 to 8 are more controversial. Given the expected beneficial impact of the previous points, and other tradition stimulants that could have been added, some additional rationale besides encouraging exploration must be sought. Two alternatives seem the most logical. First, Petro-Canada could be used as a vehicle for Crown exploration. The Government of Canada through Petro-Canada is presently engaged in joint exploration ventures with private companies. After a sufficiently "learning by doing" period Petro-Canada could be used either to supplant private exploration or to augment private exploration where it was felt to be insufficient. However, it is not clear to us what advantages public exploration has over private exploration provided that oil and gas exploration and production are governed by a sensible system of regulationss

Second, Petro-Canada could be used as a vehicle to eliminate (oligopoly) rents. If barriers to entry into the industry exist because of economies of scale and/or economies of integration then it is possible that industry output is restricted. Energy prices will be relatively higher than they would be if the industry was behaving competitively. Petro-Canada, by acting as the dominant firm in the industry, can induce the private firms to behave competitively. In this situation it might be necessary for Petro-Canada to enter the exploration and production stages of the industry (along with other stages) to provide its regulation service effectively and efficiently.[10]

The discretionary powers of intervention given the Minister are the most difficult to rationalize. One would expect that these discretionary powers would increase the uncertainty in an industry already beset with uncertainty. Ministers and governments can change. The consequent uncertainty in the minds of industry participants regarding the policies behind the behavior of government officials could have a deleterious effect on investment.

Finally, the Canadian participation requirements can not be justified on the basis of economic analysis. Their effect is to reduce the level of investment by foreigners in Canadian exploration.

APPENDIX A: TABLES

TABLE A1
Summary of Oil and Natural Gas Resources of Canada - 1975*
(Remaining Reserves, Discovered Resources and Undiscovered Potential)

	Likelihood of Existence		
	"High" 90% Probability	50/50 Chance 50% Probability	"Low" 10% Probability
	Oil Resources (billions of barrels)		
REGION			
Atlantic Shelf South.............	1.2	1.9	3.0
Labrador-East Newfoundland Shelf.	1.7	2.6	4.5
Northern Stable Platform Basins..	0.01	0.6	3.2
St. Lawrence Lowlands............	0.04	0.09	0.2
Western Canada...................	10.9	11.7	13.5
Mainland Territories.............	0.3	0.5	1.0
Mackenzie Delta-Beaufort Sea.....	4.3	6.9	12
Sverdrup Basin...................	1.1	2.0	4.0
Arctic Fold Belts................	0.5	1.8	4.3
Total Canada (Accessible Regions)	25	30	43
	Gas Reserves (trillions of cubic feet)		
REGION			
Atlantic Shelf South.............	8.6	13.2	20
Labrador-East Newfoundland Shelf.	18	26.7	45
Northern Stable Platform Basins..	0.4	2.3	12
St. Lawrence Lowlands............	0.7	1.4	3.2
Western Canada...................	89	97	107
Mainland Territories.............	6.0	9.7	20
Mackenzie Delta-Beaufort Sea.....	39	60	99
Sverdrup Basin[2]................	21	40	80
Arctic Fold Belts................	2.9	11	26
Total Canada (Accessible Regions)	229	277	378

NOTE: These columns do not total arithmetically to the Canada totals because individual curves must be summed using a statistical technique.

*Prepared by Geological Survey of Canada.

[1]Extracted from "Oil and Natural Gas Resources of Canada, 1976," Department of Energy, Mines and Resources.

[2]The Sverdrup Basin is main area of sedimentary accumulation in the Arctic Islands.

TABLE A2

PARTICIPATION AND CAPITAL SHARE DISTRIBUTION

PANARCTIC OILS LTD.

	Initial $20 Million Financing (late 1967) Preferred Shares	Common Shares	Next $10 Million Financing (early 1970) Preferred Shares	Common Shares	Next $20 Million * Financing (Mid-1970) Preferred Shares	Common Shares	Amount *	Equity* %
Government of Canada	900,000	225,000	450,000	112,500	900,000	225,000	$22,556,250.00	45.00000
Bankeno Mines Limited	45,175	11,294	22,588	5,647	45,175	11,294	1,132,203.50	2.25875
Bocadel Oil Corp.	90,349	22,587	45,174	11,294	90,349	22,587	2,264,366.80	4.51745
Bow Valley Industries Ltd.	45,175	11,294	22,588	5,647	45,175	11,294	1,132,203.50	2.25875
Campbell Red Lake Mines Limited	8,131	2,033	4,066	1,016	8,131	2,033	203,788.20	.40655
Canadian Gridoil Ltd.	18,973	4,743	9,486	2,371	18,973	4,743	475,505.70	.94865
Canadian Industrial Gas & Oil Limited	13,552	3,388	6,776	1,694	13,552	3,388	339,647.00	.67760
Canadian Nickel Company Limited	90,349	22,587	45,174	11,294	90,349	22,587	2,264,366.80	4.51745
Canadian Pacific Oil & Gas Limited	180,698	45,174	90,349	22,587	180,698	45,174	4,528,743.50	9.03490
Cominco Ltd.	180,698	45,174	90,349	22,587	180,698	45,174	4,528,743.50	9.03490
Connelly, E.	2,259	565	1,129	282	2,259	565	56,611.20	.11295
Conick Petroleums Ltd.	5,421	1,355	2,710	678	5,421	1,355	135,858.80	.27105
Dome Mines Limited	16,263	4,066	8,132	2,032	16,263	4,066	407,596.40	.81315
Dome Petroleum Limited	81,314	20,329	40,657	10,164	81,314	20,329	2,037,932.20	4.06570
Eagle Ridge Petroleum Ltd.	90,349	22,587	45,174	11,294	90,349	22,587	2,264,366.80	4.51745
Excel Petroleums Ltd.	45,174	11,294	22,588	5,647	45,174	11,294	1,132,183.50	2.25870
Noranda Mines Limited	90,349	22,587	45,174	11,294	90,349	22,587	2,264,366.80	4.51745
Sigma Mines (Quebec) Limited	2,711	678	1,356	339	2,711	678	67,949.50	.13555
Scenic Oils Ltd.	2,711	678	1,356	339	2,711	678	67,949.50	.13555
Thor Exploration Company Ltd.	90,349	22,587	45,174	11,294	90,349	22,587	2,264,366.80	4.51745
	2,000,000	500,000	1,000,000	250,000	2,000,000	500,000	$50,125,000.00	100.00000%

* Probable Participation, Amount and Equity, following the third stage financing.

TABLE A3

ACREAGE COMMITTED TO PANARCTIC OILS LTD.

FARMOR	TOTAL ACREAGE UNDER AGREEMENTS	PERCENTAGE TO BE EARNED UNDER FARMOUT (MAX. PROGRAM)	ACRES EARNED UNDER MAX. PROGRAM*
Alminex	1,986,821	85%	1,688,797.8
Bankeno Mines et al	1,920,933	80%	1,536,746.4
B. P. Exploration	3,297,359	80%	2,637,887.2
Canada Southern	709,135	80%	567,308.0
Canada Southern) B. P. Exploration)	62,650	80%	50,120.0
Canada Southern) Clark, Skelly)	57,210	80%	45,768.0
Canadian Gridoil	1,316,546	80%	1,053,236.8
Canadian Homestead	1,227,652	85%	1,043,504.2
Canadian Industrial Gas & Oil	822,701	85%	699,295.8
Canadian Montana Gas	495,397	80%	396,317.6
Chevron Standard	1,071,598	50%	535,799.0
Cominco & Bankeno	3,637,781	80%	2,910,224.8
Consumer's Co-op	1,482,542	85%	1,260,160.7
Dome Petroleum	2,432,102	50%	1,216,051
Dominion Explorers	4,030,394	75%	3,022,795.5
Francana Oil & Gas	1,779,245.5	85%	1,512,358.7
Great Plains	3,863,359.5	50-60%	2,089,060.1
Kuma Oils	722,637	90%	650,373.3
Norpet Oil & Gas Ltd.	449,365	85%	381,960.3
Panarctic Oils Ltd.	5,494,738	100%	5,494,738
Pembina Pipe Line	660,983	80%	528,786.4
Petropar Canada	2,327,186	80%	1,861,748.8
Plains Petroleum et al	1,303,878	85%	1,108,296.3
Prairie Oil Royalties	1,526,213	77.5%	1,190,565.1
Wm. R. Sheeky	85,490.5	80%	68,392.4
B. E. Thouvenelle	162,633	85%	138,238.0
Trans-Western Oils (Axel-Heiberg)	25,324	80%	20,259.2
Trans-Western Oils (Ellef Ringnes)	24,958	90%	22,462.2
Triceetee Group	3,687,097.5	80%	2,949,675.6
United Canso (Devon-Axel Heiberg)	1,062,947	80%	850,357.6
United Canso (Somerset)	1,720,780	66-2/3%	1,147,071.9
Western Minerals	792,620	90%	713,358
Totals	50,240,276.0	---	39,391,714.7

Total % Acreage Earnable - 79.5% of Acres Farmed Out.

* The net acreage shown assumes that all farmout options exercised.

TABLE A4

Exploration Permits - Arctic Islands

Year	Permits Issued #	Permits Issued Acreage	Permits Terminated #	Permits Terminated Acreage	Permits Outstanding #	Permits Outstanding Acreage
1960	856	42,500,111			864	42,631,455
1961	107	4,147,087			971	46,778,542
1962	156	5,924,626			1,127	52,703,168
1963	190	9,324,331	329	17,795,685	988	44,231,814
1964	127	7,605,836	48	2,062,190	1,067	49,775,460
1965	194	8,641,323	142	7,016,959	1,119	51,399,824
1966	317	14,237,559	10	700,861	1,426	64,936,522
1967	224	8,844,477	--	--	1,650	73,780,999
1968	2,240	114,575,277	6	333,765	3,884	188,022,511
1969	1,320	69,710,315	1	22,941	5,203	257,709,885
1970	271	14,883,234	226	16,039,470	5,248	256,503,649
1971	582	34,855,365	362	23,285,649	5,468	268,073,365
1972	138	6,183,080	111	6,302,541	5,495	267,953,904
1973			471	24,354,632	5,024	243,599,272
1974			75	3,335,539	4,959	240,264,733
1975			349	18,058,044	4,610	222,206,689
1976			947	48,608,733	3,663	173,597,956

*No new permits were issued after March 21, 1972.

TABLE A5

Drilling Statistics - Arctic Islands

Year	Total # of wells	Dry and abandoned	Oil	Gas	Depth Drilled (feet)
1962	1	1			12,543
1963	1	1			4,840
1964	1	1			10,000
1965	-	-			--
to					
1968	-	-			--
1969	2	2			11,070
1970	7	5		2	60,127
1971	16	14		2	135,092
1972	20	14	2	4	169,703
1973	23	20		3	195,788
1974	23	18	1	4	210,214
1975	14	11	1	2	121,331
1976	12	8	4	3	98,139

North of 60

1) Oil and gas Statistical Report No. 2, 1921-1972, Indian and Northern Affairs.

2) Oil and Gas Activities, 1973, 74, 75, 76, 77.

FOOTNOTES

1. See Energy, Mines and Resources Canada [1976]. Parts of this proposal are in effect pursuent to Order in Council P.C. 1977-2155. The paper considers the proposed legislation as detailed in the Statement of Policy.

2. See Table A1 for the relative importance of the oil and natural gas resources of the Arctic Islands to Canada.

3. See Uhler [1976] for empirical estimates of exploration costs in Alberta.

4. Technical, geological, market and political risks are greater in frontier exploration. Large scale exploration reduces these risks through risk pooling.

5. See Indian and Northern Affairs [1968], North of 60, Oil and Gas Activities.

6. The cost estimates of this section were obtained grom Hetherington [1971, 1973, 1976] and from discussions with other Panarctic Officials. C.H. Hetherington is the President and Chief Executive Officer of Panarctic Oils Ltd.

7. See Winkler [1972] for a discussion of Bayesian statistical inference and decision.

8. The Geological Survey of Canada is a government agency which began collecting geological information of the area, made publicly available, in the 1880's. The information available at the time of the public auction would be reflected in the prices obtained by the government for the tracts of land.

9. Order in Council P.C. 1977-2155 stipulates that where an application is made for a special renewal permit in respect of which no declaration of a significant discovery is in force at the time the application is made, Petro-Canada shall, on application therefor, have the right to be granted

   a) where the Canadian participation rate of the applicant for the special renewal permit is twenty-five percent or more but less than thirty-five percent, a ten percent interest in the special renewal permit to be granted to Petro-Canada; and

   b) where the Canadian participation rate of the applicant is less than twenty-five percent, an additional interest in the permit, not exceeding fiften percent, of one percent for every one percent that the Canadian participation rate falls below twenty-five percent.

10. See Wiens [1979] for an anlysis of the dominant firm role of Petro-Canada.

REFERENCES

Alchian, A.A. and H. Demsetz [1972] "Production, Information Costs, and Economic Organization," American Economic Review, 62, 777-795.

Alchian, A.A., R.G. Crawford, and B. Klein [1977] "Vertical Integration and Ownership of the Firm," U.C.L.A. Discussion Paper No. 103.

Buchanan, J.M. [1973] "The Coase Theorem and The Theory of the State," Natural Resources Journal, 13, 579-594.

Crommelin, M., P. Pearse, and A. Scott [1978] "Management of Oil and Gas Resources in Alberta: An Economic Evaluation of Public Policy," Natural Resources Journal, 18, 337-389.

Canada Oil and Gas Land Regulations [1961]: established by Order in Council P.C. 1961-797 plus amendments.

Energy, Mines and Resources Canada [1976]: Statement of Policy, Proposed Petroleum and Natural Gas Act and New Canadian Oil and Gas Land Regulations.

Gilbert, R.J. [1976] "Search Strategies for Nonrenewable Resource Deposits," Technical Report No. 196, Institute for Mathematical Studies in The Social Sciences, Stanford University.

Gordon, H.S. [1954] "The Economic Theory of a Common-Property Resource: The Fishery," Journal of Political Economy, 62.

Grayson, C.J. [1960] Decisions Under Uncertainty: Drilling Decisions by Oil and Gas Operators, Harvard University.

Harris, R.G. and E.G. Wiens [1977] "Government Enterprise: An Instrument for the Internal Regulation of Industry," Carleton Economic Papers, No. 77-13.

Hetherington, C.R. [1971] "Panarctic Provides Impetus," Canadian Petroleum, October.

Hetherington, C.R. [1973] "Oil and Gas Exploration in the Canadian Arctic Islands," A Presentation to the Exploration Seminar of the New York Society of Security Analysts.

Hetherington, C.R. [1976], "High Arctic Challenge and Potential," Canadian Petroleum, February.

Hirschleifer, J. [1971] "The Private and Social Value of Information and the Rewards to Inventive Activity," American Economic Review, 61, 561-574.

Indian and Northern Affairs, Government of Canada: North of 60, Oil and Gas Activities, 1968-1978.

Maxwell, J. [1973] Energy from the Arctic: Facts and Issues, Montreal, D.C. Howe Research Institute.

McKie, J.W. [1950] "Market Structure and Uncertainty in Oil and Gas Exploration," Quarterly Journal of Economics,

McManus, J.C. [1975] "The Costs of Alternative Economic Organizations," The Canadian Journal of Economics, 8, 334-350.

Miller, E. [1973] "Some Implications of Land Ownership Patterns For Petroleum Policy," Land Economics, 49, 414-423.

Panarctic Oils Ltd., Annual Reports, 1967-1978.

Petersen, F. [1975] "Two Externalities in Petroleum Exploration," in Brannon, G. (ed.), Studies in Energy Tax Policy, Ballinger, Cambridge, Mass.

Petro-Canada, Annual Reports, 1976-1978.

Ritchie, R.S. [1975] "Public Policies Affecting Petroleum Development in Canada," Canadian Public Policy, I:I.

Stiglitz, J. [1975] "The Efficiency of Market Prices in Long Run Allocations in the Oil Industry," in Brannon, G. (ed.), Studies in Energy Tax Policy, Ballinger, Cambridge, Mass.

Teece, D.J. [1976] Vertical Integration and Vertical Divestiture in the U.S. Oil Industry, Institute for Energy Studies, Stanford University.

Teece, D.J. [1976] "Economies of Scope and the Scope of the Enterprise: The The Diversification of Petroleum Companies," Discussion Paper #32, Center for the Study of Organizational Innovation, University of Pennsylvania.

Uhler, R.S. and P.G. Bradley [1970] "A Stochastic Model for Determining The Economic Prospects of Petroleum Exploration Over Large Regions," Journal of the American Statistical Association, 65, 623-630.

Uhler, R.S. [1976] "Costs and Supply in Petroleum Exploration: The Case of Alberta," Canadian Journal of Economics, 9, 72-90.

Wiens, E.G. and R.G. Harris [1978] Petro-Canada: An Instrument of Government Policy, study prepared for the Department of Energy, Mines and Resources, Government of Canada, Ottawa, Canada.

Wiens, E.G. [1978] "A Theory of Government Firm Regulation," U.C.L.A. Discussion Paper No. 134.

Wiens, E.G. [1979] "Petro-Canada, Antitrust Legislation, and Vertical Integration in the Canadian Petroleum Industry," Discussion Paper #41, Center for the Study of Organizational Innovation, University of Pennsylvania.

Williamson, O.E. [1975] Markets and Hierarchies: Analysis and Antitrust Implications, Free Press, New York.

Williamson, O.E. [1979] "Governance Structures and Contractual Relations," Discussion Paper #37, Center for the Study of Organizational Innovation, University of Pennsylvania.

Winkler, R.L. [1972] An Introduction to Bayesian Inference and Decision, Hole, Rinehart and Winston, New York.